The Betting Line on Beef: Ex-ante Estimates of Improved Pasture Research Benefits for the Latin American Tropics

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The paper estimates that the expected returns to improved pasture research (IPR) in the Latin American tropics are very high and suggests that current research on IPR is significantly underfunded. Although increased competition from poultry may reduce future regional beef consumption, regional beef consumption and production decisions can be divorced provided that beef surpluses can be exported. Current international beef prices are in fact biased downward due developed country protection. Shadow international prices, adjusted for the probability of eliminating current distortions in the long run, should be used when setting research priorities for investments which have such a long pay-out period. Such shadow international prices call for even higher expenditures on IPR. The estimates of IPR are further increased when their impact on milk as well as beef production is considered. Equity concerns suggest need for special effort to develop pasture technologies for areas where small farms engage in joint milk-beef production.

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Carlos Sere and Lovell Jarvis

Introduction.

The Latin American tropics contain vast areas of low fertility, acid soils which currently contribute little to agricultural production. Nonetheless, these soils have the potential to produce very large amounts of beef and milk, provided that a suitable improved pasture technology can be developed. This paper estimates the expected benefits of research on grass-legume pastures for the Latin American tropics and demonstrates, using what we believe are conservative assumptions, that the development of such technology should yield a high return on the investment and very large total benefits. Because Latin America is one of the few areas in the world capable of providing an increase in low-cost pasture-based beef production, these results have relevance for the world beef market. We conclude that current research on improved pastures is significantly underfunded.

In the early 1980s, G. A. Nores (unpublished; see also CIAT 1986) predicted high returns to improved pasture research. Nores assumed a closed economy context, and took no account of the potential impact on beef demand of substitutes like poultry. Traditionally, beef has been the dominant meat in Latin American diets (Muchnik de Rubenstein and Nores 1980, Jarvis 1986, Lynam 1987). In the last two decades, however, poultry's price has fallen relative to that of beef and poultry's share in

consumption has risen steadily in most countries (Rivas et al 1987, Lynam 1987).

Poultry production in Latin America has increased at an annual rate of 7 percent during the past two decades, nearly three times that of beef. Poultry's price should continue to decline relative to beef, and poultry's consumption share should expand further. Within the international agricultural research community, some argue that continuing decline in poultry's price will lead to declining demand for beef, lower beef prices, and a lower return to beef production research, and recommend that research resources be shifted from beef, e.g., improved pastures, toward feed grains and substitutes.

In this scenario, an outward shift in poultry supply (not shown) causes an inward shift in beef demand from D_0 to D_1 (Figure 1). As a result, the benefits of improved pasture research (IPR)--which is assumed to reduce beef production costs, pivoting the beef supply curve from S_0 to S_1--decline from ØAB to OCD, measured as the sum of producer and consumer surplus. A significant proportion of the value of IPR is lost due to increased poultry competition.

We propose a different scenario in the belief that international trade will provide a floor to the beef price, allowing the choices between production and consumption to be divorced once exports begin (Figure 2). Thus, the benefits of IPR are OAEF without increased poultry competition and OGF with poultry. Even if the poultry's price declines and poultry's share of consumption rises, the price of beef will fall

relatively little and could even rise if the demand for beef increases internationally. Latin American countries could thus experience a rising beef price and falling domestic beef consumption, along with higher beef production and exports--and higher poultry consumption. The availability of cheaper poultry would allow beef's price to rise with much less harm to low income Latin American consumers. This possibility suggests that beef and poultry production research are not necessarily rival in Latin America.

The above argument indicates that the profitability of IPR will depend importantly on the level of international beef prices, which is known to depend on the economic policies of developed country beef producers, e.g., the United States, the EC, and Japan (e.g., Jarvis 1986, Sere and Jarvis 1987, and Alston, Edwards and Freebairn 1987). Several recent studies have estimated that international beef prices would increase by 16 to 20 percent if protectionism in beef importing countries were eliminated (e.g., Valdes 1987). If protectionism were eliminated or reduced in the future, the rate of return to IPR in the Latin American tropics should therefore rise significantly.

Because IPR could have a significant impact on the distribution of income via its differential effects on countries, regions, and consumers and producers, this paper also examines some of the primary distributional issues and their implications for research policy.

Beef Production In Latin America

Latin America has a strong comparative advantage in beef

production and great potential for increasing beef production via tropical pasture research. Cattle production has been the predominant form of land use in Latin America since its colonization by the Spanish and Portuguese in the 16th Century. Cattle production fitted well into the region's resource endowment: ample land, frequently with limitations on crop production, low population density, and limited infrastructure. Latin America now has approximately 318 million cattle, or 25 percent of the world's stock (CIAT 1987), in two major production regions. The temperate region is comprised mainly of Argentina, Chile, and Uruguay and the tropical region is comprised of the rest of South and Central America, plus much of Mexico and the Carribean.

The two regions utilize markedly different cattle production technology. The temperate zone has great similarity with temperate regions in the developed world, from which it has been able to transfer technology including animal breeds, pasture germplasm, and animal health interventions (Productivity levels are lower in Latin America mainly because of differing output/input relative prices).

The tropical region has a climate less condusive to animal growth, forages are of generally poorer quality, and the disease and parasite threat is greater. The relatively lower amount of tropical livestock research in developed countries makes technology transfer to the tropical region less feasible. In addition, the rate of technical progress in the beef industry in the Latin American tropics is determined primarily within Latin America insofar as the most important technological constraint is land

specific.

During 1976-81 beef production averaged about 49 kg/head in the temperate region, but only about 24 kg/head in the tropical region. Nutrition is the main factor limiting production (e.g., Wheeler 1984). The tropical region possesses 249 million cattle, or 78 percent of Latin America's cattle. Fortunately, the tropical area has the potential to substantially increase its production via improved pastures.

Introduction of new forage species over a period of several hundred years has contributed to expansion of tropical livestock production in Latin America. To date, expansion has been based almost exclusively on grass species such as Panicum maximum for fertile soils and Brachiaria decumbens on acid soils. Nonetheless, the tropical pastures remain of significantly poorer quality than most temperate pastures and such pastures have also been attacked by diseases and pests (e.g. spittlebug), drawing attention to the high risk of operating on the currently very narrow pasture genetic base in the tropical region.

Pasture productivity can be further increased through the development and introduction of suitable legume-grass pasture mixes which make possible higher production per animal and per hectare, while also offering more persistent and stable animal nutrition. One role of the legume-grass mix is to reduce the seasonal fluctuation in pasture availability caused by the marked dry season prevailing throughout this region, thus increasing the productivity of such lands. The improved productivity from savanna pastures can, under plausible circumstances, reduce the

pressure to develop the fragile humid tropics, while also releasing more fertile land presently under pastures for more intensive crop production.

The potential payoff to pasture research has been highlighted in recent years by results obtained at several research stations. For example, at Carimagua on the eastern plains of Colombia, the Instituto Colombiano de Agricultura and the Centro Internacional de Agricultura Tropical (CIAT) have screened forage legumes and grasses and obtained dramatic increases in stocking rates and in production per animal. Economic analysis has shown that such technologies yield high rates of return at current prices -- about 30% (Sere 1986). Scope exists for even higher profitability via reduced pasture establishment costs (e.g., soil preparation, combination with crops, and fertilizer and seed requirements), which is expected with further research.

Research involves primarily the domestication of wild tropical plant species, a process implying substantial long term investments. There is no existent stock of knowledge to permit easy development of varieties suitable for the tropics, as was the case for the first "Green Revolution" crops, wheat and rice. The diffusion of improved pastures, once refined, is expected to require many years. Ranchers in most areas have been cautious when adopting new pastures. Pasture establishment is costly and moderately risky. Pastures can fail because of disease, pests, weather, or poor grazing management -- and management is a skill which has to be learned through doing. These problems have limited the adoption of grass-legume pastures in temperate Latin America (Jarvis 1980) and will probably affect the adoption of

similar pastures in tropical areas (However, the effort to develop pasture technology specifically for tropical areas should yield better results than was attained in the temperate areas where pasture technology was imported without significant local adaptation). Further, pastures can expand no faster than the livestock herd which has its own biological limitations.

Methodology

Although an important investment is already being made in improved pasture research, we hypothesize that the high level of expected benefits would justify substantially higher research expenditures. Given the objective of documenting the orders of magnitude of the research benefits of IPR, and the lack of specific information regarding many variables, we have needed to make a number of assumptions. When alternative assumptions were plausible, we chosen the one which we considered most likely, but have tried to err on the conservative side to ensure that our estimates yield a lower bound for IPR benefits. In several important cases we show the effect of different assumptions.

The need to make assumptions regarding important parameters clearly increases the risk of error and the problem is exacerbated by the expectation that improved pastures will achieve their full impact only after a long period. Estimating benefits in the distant future requires, in particular, estimating prices in the future under what may be supply and demand conditions quite different from those prevailing today. Use of a relatively high discount rate automatically reduces but does not eliminate the impact of distant events.

IPR benefits are evaluated in terms of producer and consumer surplus, given the estimated impact of IPR on the supply curve over a 50 year period (Figure 1). The choice of linear versus non-linear supply and demand curves, as well as the choice of pivotal versus parallel shifts can have a significant impact on the estimated level of benefits and on their distribution between consumers and producers (Miller, Rosenblatt, and Hushak 1988, Duncan and Tisdell, Lindner and Jarrett 1978, and Norton and Davis 1981). For ease of calculation and lack of any strong evidence to the contrary (at least for changes of the magnitude discussed here), we utilize linear supply and demand functions.

We allowed the supply curve to begin at the origin rather than at a positive intercept, say US$500, thus increasing the benefits to IPR. In turn, we chose a pivotal rather than a parallel K shift (Linder and Jarrett 1978), which reduces the benefits of IPR. As we have no strong evidence in favor of either, we selected a combination -- beginning at the origin and a pivotal K shift -- which produces intermediate benefits.

The current supply curve was estimated by drawing a line from the origin to the coordinate of current price and regional output. Initial beef production is that reported for 1985, 4.73 million tons. Because the tropical region is practically self-sufficient in beef, the initial domestic price is set at US$1625/ton carcass weight, mid-way between the estimated import and export prices. This yields a supply elasticity about the current price of approximately 1, a value which approximates the only available estimates for the long run beef supply elasticity

in Latin American countries: Argentina - 1.15 (Yver 1971) and Brazil - 1.56 (Lattimore and Schuh 1979).

The FOB export price chosen is US$1500/ton, roughly the current price and 5 percent below Uruguay's 25 year average FOB price. The CIF import price is the Uruguayan export price plus $300/ton freight costs (Longmire and Gardiner 1984). Uruguay, a traditional Southern Cone exporter, has endemic foot and mouth disease (FMD). Countries free of FMD, which include Mexico and Central America, export beef at a price approximately 20 percent higher (Jarvis 1986), so we underestimate the benefits to IPR investments in such countries.

We assume that in the absence of IPR any increases in regional beef demand caused by population and income growth would be just offset by increases in regional beef supply unrelated to IPR. This assumption, which permits us to measure the effect of IPR by referring to current demand and supply schedules, is believed to also produce a conservative estimate of IPR benefits. Without IPT, regional beef demand should increase significantly more rapidly than supply in the future. For 1960-1985, beef demand and supply in tropical Latin America increased at about 5 percent and 2 percent, respectively, and internal prices have trended upwards while (net) exports have declined. Beef production increases in recent decades have been achieved largely through expansion into unutilized savanna lands, but few additional lands are available. Thus, the beef supply schedule should become significantly more inelastic unless new technologies are developed.

The elasticities of regional beef demand with respect to

beef price and poultry price are assumed to be -0.40 and 0.50, respectively, based on recent econometric estimates for countries in the area (Rivas et al 1987).

International prices are assumed to remain constant over 50 years. International prices for beef exported from foot-and-mouth endemic regions have cycled about a roughly constant trend during 1955-1987, though prices showed an increasing trend to 1975 and a decreasing trend thereafter, largely due to increased protection in developed country importers (Jarvis 1986). It is extremely difficult to predict whether the increased demand from higher incomes and population will be offset by technical change, permitting lower cost production.

Experimental on-farm trials with legume-grass pastures of the type discussed here have been established under farmer control in the Carimagua, Colombia region in recent years. These pastures have increased output from 15 kg/ha to 300 kg/ha through adoption of the improved pastures. We assume adopting farmers will average 200 kg/ha; on average, farmers implementing new agricultural technologies achieve 66 percent of experimental yields (Davidson and Martin 1966). Use of .5 as the liveweight to carcass weight conversion factor results in an expected beef production increase of .0925 tons of beef (carcass weight) per hectare sown to improved pastures.

Sanchez and Tergas (1979) have estimated that the Latin American tropics contain 880 million hectares of acid infertile soils, the types for which improved pasture technologies are being developed. This area contains substantial humid tropic

areas (rainforests) whose conversion to pastures is highly controversial because of possible ecological damage. We assume that no adoption of improved pastures occurs in areas of current humid forests. Were it to occur, any returns to IPR would be higher than indicated by the estimates in this paper unless offset by environmental externalities.

Fortunately, Latin America contains vast grassland areas which are already used for livestock production and where production can be increased significantly without environmental degradation, e.g., there are approximately 370 million ha in the Cerrados and savannas, plus those areas of rainforest already being used. Approximately 10 million hectares of rainforest have already been converted to pastures, of which roughly 5 million hectares have degraded to the extent that they are abandoned (Toledo 1988). These improved pasture technologies would permit the profitable recovery and long term use of such land, increasing production and reducing current ecological damage.

We assume this reduced area of 380 million hectares is the area potentially available for improved pastures. Of this area, we assume that a maximum of about 10 percent would be planted in to improved pastures. Jarvis (1981) estimated that the adoption of improved grass-legume pastures in temperate Uruguay would reach a ceiling of about 11 percent of total pasture area in less than 20 years. The expected technical superiority of the grass-legume pastures being developed for tropical areas should result in a ceiling which exceeds this proportion.

We assume that the area planted to improved pastures is proportional to the beef price prevailing, i.e., the hectares

sown at P_0 and P_1 are shown by the line segments LB and AK (Figure 1). We further assume that adoption follows a logistic process, requiring 50 years for virtual completion. Studies of other diffusion processes have revealed that highly profitable new technologies have generally been widely adopted and the entire process has been complete in 20 years or less. A longer period is reasonable in this case because specific technological packages will have to be developed for different regions and the management improvements needed will require time.

Finally, we calculate the present value of IPR using a 10 percent discount rate, where the annual benefits achieved reflect the shift in the supply achieved by IPR, gradually pivoting the supply curve from S_0 to S_1. The total shift is partitioned into small annual shifts by use of the logistic function which determines the time path of the hectares planted to improved pastures, and thus the resulting incremental changes in livestock production. Each annual shift generates a set of total, consumer and producer surpluses, whose sum, discounted, provides a net present value. The 10 percent real discount rate is believed high.

IPR has been underway for about a decade. Some diffusion of improved grass, and a very small amount of grass-legume pastures, has occurred as a result of past research efforts. No evidence is available regarding the expected future diffusion of improved pastures were the research process terminated, nor, for that matter, regarding the incremental benefits which might be associated with each level of incremental research investments

provided the latter are continued. To compare the estimated potential benefits of IPR with associated incremental expenditures we first convert the present value of IPR benefits into a 50 year annuity using a 10 percent interest rate. This calculation yields the maximum economic annual flow of future research expenditures, assuming that past research investments are sunk costs and that no significant diffusion of improved pastures would occur without further research developments. The latter assumption leads us to overestimate the returns to future IPR provided that some diffusion would occur in any event. We doubt the error is large because few commercial packages have yet been released. Past research has primarily established the technical and economic viability of the basic approach.

We then go a step further by estimating the internal rate of return to improved pasture investments given both the stream of benefits previously calculated and also an estimated level of expenditure assumed required to develop and then maintain such benefits. Within this framework we also examine the effect of delaying the on-set of research benefits.

Finally we examine the effect which increased poultry competition might have on beef demand and, thereby, on the expected profitability of IPR. The price of poultry has declined at 2.8 percent per year during the last 25 years in Brazil, the country in which the greatest price reduction has been achieved. We project a similar price decline for the whole region for 50 more years, allowing the price of poultry to fall to one fourth its current level. Although such a price decline seems extreme, this assumption provides for the largest realistic negative

impact from poultry competition on the returns to IPR. A cross price elasticity of 0.5 between poultry and beef is used to estimate the associated reduction in regional beef consumption, i.e., the shift from D_0 to D_1. If the price of poultry is assumed to decline less, e.g., to one half its current level, the effect would be to increase the consumption of beef and, thus, beef's price -- at least within a closed economy -- with consequently higher returns to IPR.

Economic Returns: A First Approximation.

The present value of IPR is estimated for five scenarios: 1) a closed economy in which poultry has no marginal impact on beef demand, 2) an open economy otherwise identical to case (1), 3) a closed economy, in which poultry competition reduces domestic demand for beef, 4) an open economy otherwise identical to case (3), and 5) an open economy in which poultry competition reduces beef demand, but where international price is 10 percent above its current level.

The estimates shown in Table 1 reflect the potentially high increases in production per ha which can be achieved over a large geographical area. The results may be summarized as follows:

a) The estimated return to IPR in the Latin America tropics is high even if poultry continues to substitute for beef in domestic consumption and is no exports are possible. The returns are extremely high if beef surpluses can be exported at prices close to historical levels or above. For example, in case (1), a closed economy without competition from poultry, the estimated total surplus is $2.8 billion. In case (3), a closed economy in

which beef encounters severe competition from poultry, the total surplus remains $1.8 billion. The latter is clearly a worst-case scenario occurring only if world markets are closed to increased beef exports from this region. In the more optimistic case (5) with beef export prices 10 percent higher due to a reduction in international protection of beef markets (or perhaps due to the erradication of foot and mouth disease within the Latin American tropics), total benefits are US$3.5 billion. Finally, in case 4) with an open economy, competition from poultry, and beef prices at current levels, the present value is $2.9 billion.

b) Use of a 10 percent discount rate implies an annual annuity ranging from US$180 million to US$350 million. (These amounts are dramatically higher if lower discount rates are used.) For comparison, current research and extension expenditures in the region are estimated to be approximately US$20 million. The discrepancy between the level of current expenditures and the level which the expected benefits of IPR would apparently justify can be reconciled only if the potential benefits from IPR have previously been vastly underestimated, if policy makers have assigned a very low value (about 5 percent) to the probability of achieving "success" as we have defined it, or if policy makers believe that the rate of social time preference is even higher than the 10 percent assumed.

c) The closed economy model consistently leads to smaller research benefits, but opening the economy has less effect on total research benefits than on its distribution between producers and consumers. As expected, IPR research will generally

benefit consumers more than producers. The results shown here suggest that producers would be harmed in the closed economy cases. Producers' gains in the open economy cases occur relatively late in time because the first impact of increased beef production is to move the economy from self-sufficiency to the lower-price export situation.

d) Competition from poultry leads to a significant reduction in research benefits in the closed economy, but has little effect when beef trade occurs at current prices and no effect when beef export prices are 10 percent higher. In the latter case, the effect of cheaper poultry is to convert the region into a net exporter "before" IPR has its effect on beef production, and thus all of the incremental beef production achieved is exported (Figure 2).

e) IPR benefits are high even though adoption is estimated to occur very slowly, over 50 years. The estimated internal rate of return to IPR under each of the two least optimistic scenarios, (1) and (3), exceeds 100% under the assumption that expenditures are US$20 million during the next 10 years, plus US$5 million subsequently (Table 2). The internal rate of return remains attractive even if the commencement of adoption is postponed by another decade, beginning only after the research period has ended, and if benefits are truncated at 30 years (after which improved pastures have been planted on only about 7 percent of the savanna area).

The Effect of Adjustments for International Price Distortions.

The results indicate the importance of adjusting for

distorted international prices when setting long term research investment priorities provided there is reasonable belief that such distortions will be reduced or eliminated in the future. The correct prices for use in making research decisions are the border prices which are expected to prevail over time, given differing levels of government intervention, multiplied by the probability that such intervention will occur. Recent estimates suggest that current international prices are some 15-20 percent lower than prices would be were protection to cease. (Valdes 1987).

Developed country importers have reduced international beef prices through a combination of import quotas and tariffs, and domestic price supports and the subsidized export of surpluses. Because of the budgetary pressures within the United States and the EC resulting from the growing costs of protection, and the framework for multinational negotiations established within the Uruguay Round, we believe it reasonable to expect that international prices over the long run will average 10 percent above current levels even if there is no other change in the underlying structure of supply and demand. Such higher prices would increase the expected present value of IPR to US$3.5 billion, and thus justify still higher research expenditures.

Current international price distortions, via their effect on research expenditures, have potential to seriously distort long term technology and production capacity. Within Latin America, lower border prices will discourage research and lead to a suboptimal long term production capacity. In the developed countries research would also be suboptimal if it is determined

by current border prices. However, although border prices are lowered by protection, the domestic beef prices in most developed countries are maintained at levels substantially exceeding those prevailing in "international" markets. It seems likely that livestock research -- particularly that occurring in the private sector -- may be increased by the high internal prices caused by protection, resulting in an overexpenditure on livestock research.

One question raised by the above analysis is the degree to which external markets would be able to absorb increased beef exports from Latin America. Table 3 shows the increases in beef production, consumption, and exports, as well as the change in the domestic price of beef, associated with each scenario. None of the changes appears very dramatic when seen in the context of a 50 year period. Even the increase in beef exports, which is roughly equivalent to total world beef exports in 1980, seems not so large given that world beef exports grew at 5 percent per year from 1960-1980, roughly tripling in that 20 year period.

If international trade in agricultural products is liberalized, the price of feed grains should also rise about 10 percent. This increase should make of IPR more profitable. Higher feed grain prices are unlikely to lead to significantly increased competition between crops and pastures for land use in the Latin American tropics, because soils are generally not suitable for cultivation. Regardless, there is ample area for both feed grains and pastures. However, a higher feed grain price would increase the cost of poultry nearly proportionately

in the region and internationally, stimulating both domestic and international beef demand and further raising the price of beef.

Cattle Capital As A Constraint on Pasture Adoption

Nores (unpublished) feared that the rate of adoption of improved pastures might be limited by the stock of cattle. One benefit of improved pastures is to roughly double the number of animals which can be grazed per land unit. Thus, the availability of improved pastures should have significant impact on the demand for cattle as capital goods, especially cows and young steers and heifers. If the supply of these animals is sufficiently inelastic, their prices can increase until further expansion of improved pastures is unprofitable. In this case, cattle rather than land or other inputs becomes the constraint on adoption.

Our calculations indicate that cattle will not be a constraint with the rate of pasture adoption assumed here. The Latin American tropics acid soil area currently contains about 70 million cattle. Assuming eventual establishment of improved pastures on about 38 million hectares, about 50 million additional cattle would be needed. The required annual increase should be roughly proportional to the growth shown by the logistic diffusion curve. This growth never exceeds 2.6 percent/year -- and then only briefly. That rate is far below the biological possibility of herd growth and roughly in line with the herd increases experienced in recent decades. Thus, although there will be isolated sub-regions having a small initial cattle herd and an inability to economically import other

animals wherein improved pasture adoption may be constrained by lack of cattle, e.g., the Peruvian Amazon, it should not be a problem for the region as a whole.

Milk Production and IPR Benefits.

Our analysis of IPR benefits has focused on beef production. Nonetheless, the adoption of improved pastures will permit an increase in the output of both milk and beef. We have no experimental data by which to estimate the benefits of milk, but there are strong theoretical reasons to expect that that whereever it is profitable to produce beef and milk jointly (or simply milk), the return to IPR will be higher than that calculated when only beef is produced. This can be seen heuristically as the result of a composite milk-beef price for cattle outputs which lies above the beef price and/or a larger K shift in the joint output than for beef alone (milk production responds more strongly than beef production to improved nutrition).

Joint production is more biologically efficient than specialized production in the tropics because it is genetically difficult to obtain an animal which can achieve high levels of specialized beef or milk production given the significant environmental stress and relatively low quality forage in such an area (Preston 1977). An animal with intermediate production of both milk and beef is then often more profitable, though profitability depends importantly on the costs of labor and transport as well. Joint production of milk and beef is most profitable for smaller farms having a relative abundance of labor

and access to markets. Milk production also provides a regular cash income and improved family nutrition (Von Oven 1969, Jarvis 1986, Sere and Rivas 1987).

Although tropical Latin America is largely self-sufficient in milk production, importing about 6 percent of its dairy products in 1980, its dairy imports have risen steadily during the last two decades. Domestic milk prices in most of the region's countries are maintained by protection at levels well above international prices (which are depressed by subsidized exports from developed countries, particularly the EC), thereby stimulating domestic production and restricting consumption. Improved pastures provide a means by which milk production can be increased relatively cheaply to meet growing demand while also allowing domestic prices to fall.

The provision of roads and milk collection and processing facilities will be important determinants of the extent to which milk is produced in the region, but dual purpose production is already important in many areas. Dual purpose cows (including beef cows which are regularly milked) comprise roughly 75 percent of total milk cows in tropical Latin America and, though the average yield per dual purpose cow is considerably below that of a specialized cow, dual purpose cows account for approximately 40 percent of total milk produced (Sere and Rivas 1987).

Equity Considerations.

Most of the area potentially benefited by IPR lies in several countries having especially large areas of infertile acid soils, particularly Brazil, and such countries have the greatest

incentive to invest in IPR. However, most countries in the region would benefit importantly relative to their existing livestock production and the generic technological advances being achieved by research will thus be of wide benefit.

Equity concerns should encourage development of pasture technologies suitable for use in areas having substantial milk production potential. While beef is produced predominantly on medium and large ranches, owned by relatively wealthy individuals, and using little labor, milk is generally produced on small farms and uses significant family and hired labor.

The benefits to consumers from IPR will depend primarily on the elasticity of the demand curves for milk and beef. If international trade cannot absorb significant beef exports, increased beef production will cause the regional beef price to decline. Although a price decline would reduce total research benefits, it would benefit consumers significantly. Beef accounts for roughly 50 percent of all meat throughout the region. Particularly in urban areas, where roughly two-thirds of Latin America's population now lives, beef is the most important food expenditure for every income strata and in most countries the share of income spent on beef is highest among the poor (Muchnik de Rubenstein and Nores 1980, Jarvis 1986). Individuals in higher income strata consume more beef and thus would gain most absolutely from a beef price decline, but the poor would gain as much or more proportionally to their incomes. If domestic beef prices are sustained by exports, consumer benefits would be less, but the increased output caused by IPR should cause some price decline and consumers would benefit indirectly

via increased foreign exchange revenues and economic growth. Increased milk production is more likely to benefit consumers since the region is already a net milk importer and domestic prices would have to decline significantly before exports could begin. Particularly in regions with many small farms, a high population density and adequate marketing infrastructure, milk production benefits will be skewed towards relatively lower income groups.

Because the diffusion process is likely to affect only a relatively small proportion of the total area suitable for improved pastures, we believe that improved pastures will have only moderate impact on land values. Thus, benefits will accrue to producers who adopt and learn to manage the pastures well, but not to others. Access to intermediate term agricultural credit and to competent technical assistance may be important to facilitate adoption. Investments in improved pastures will cost on the order of US$150 per hectare, and the animals needed to stock them will cost approximately US$200/ha. Although such investments should be quite profitable, many ranchers will not have sufficient internal funding to finance the desired investments, especially since the pay-out period for such investments will be 5-7 years. Technical assistance will be important to making appropriate use of the pastures since management changes will be required.

Conclusions.

The estimated returns to IPR appear very attractive. Even if poultry consumption increases substantially more in the Latin

American tropics, IPR remains highly profitable. If international markets permit beef exports at prices close to current levels, poultry and beef production are not significantly rival. The benefits to IPR appear higher yet when the potential to produce milk is added.

To derive our estimates we have been required to make numerous assumptions. While we believe these assumptions reasonable, tending to the conservative side, we emphasize their importance for the results obtained. These assumptions involve judgements regarding the shape of and shifts in the supply and demand curves for beef -- including the impact of new pasture technology, of poultry technology, income and population growth, and government intervention; the rate and ultimate level of ranch adoption of technology; and the choice of an appropriate discount rate.

We have not attempted to estimate the profitability of potential research on the production of feed grains and feed grain substitutes like cassava for the Latin American tropics, and thus to compare whether research resources for this region -- if limited -- should be spent on one commodity rather than other. Our results suggest that the potential benefits of IPR justifies much higher investment than is currently occurring. This should probably occur via an increase in total research expenditures rather than a shift from one commodity to another. If additional research funds are not forthcoming, agricultural research agencies would be required to ration the scarce existing funds among competing uses. To make appropriate choices, estimates of

the expected returns to each possible research activity in the agencies' portfolios ought to be made. That effort is well beyond the scope of this paper.

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Figure 1. Improved Pasture Research Benefits in Closed Economy With and Without Increased Poultry Competition

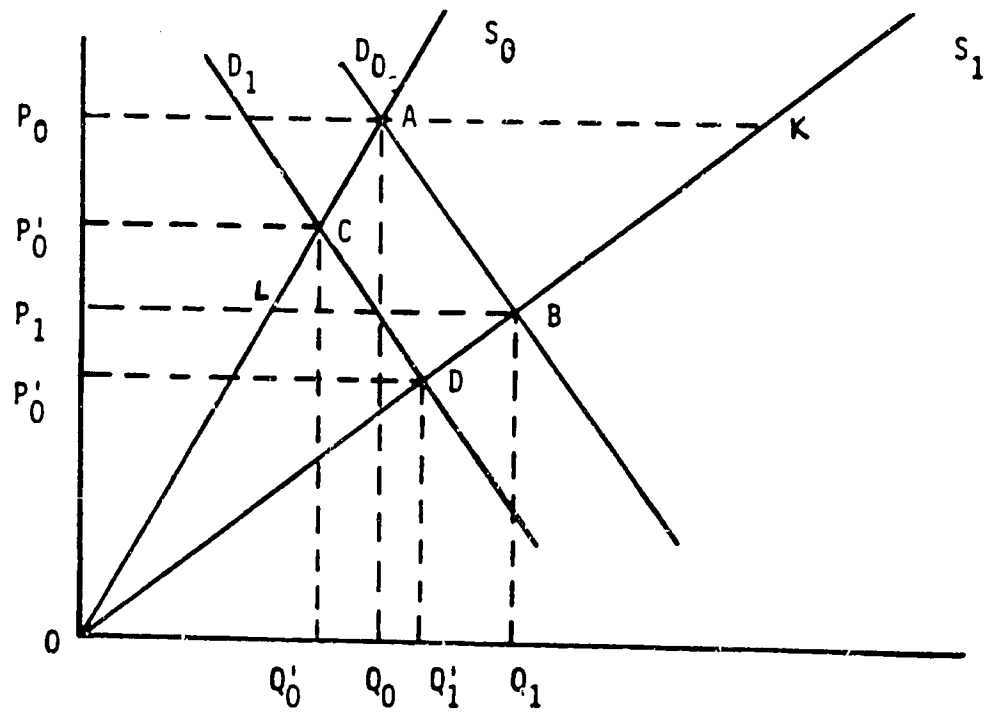

Figure 2. Improved Pasture Research Benefits in Open Economy With Increased Poultry Competition.

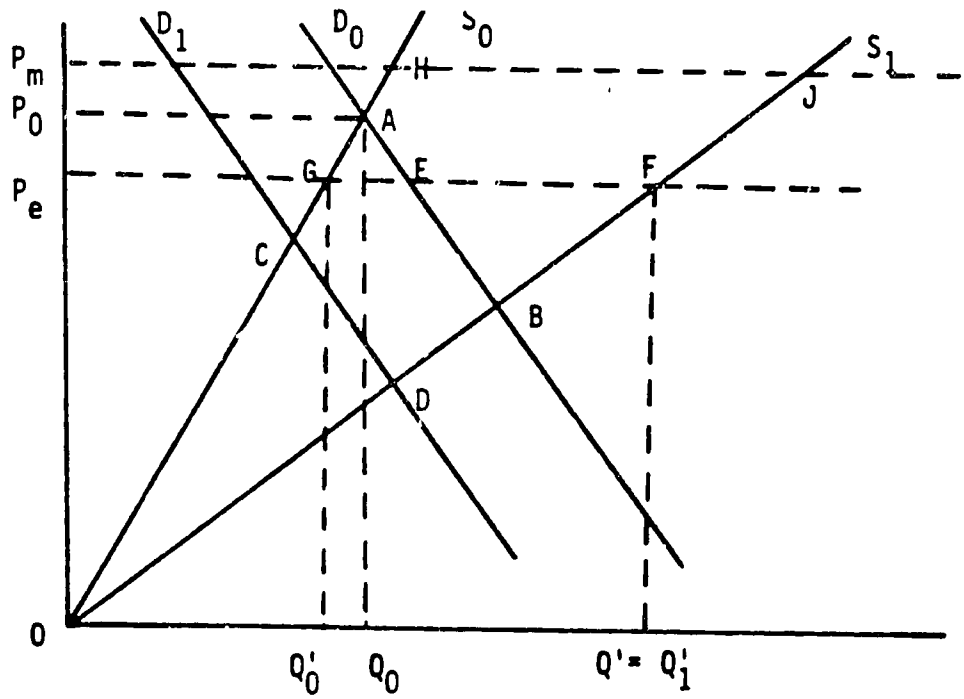

Table 1: Estimated Economic Impact[1] of Improved Pasture Research for the Latin American Tropics. (Billions, 1986 US$).

SCENARIO	TOTAL SURPLUS	CONSUMER SURPLUS	PRODUCER SURPLUS	ANNUAL ANNUITY
1. Baseline, closed economy	2.8	4.1	-1.3	0.28
2. Baseline, open economy	3.1	2.3	0.7	0.31
3. Poultry reducing beef demand, closed economy	1.8	2.7	-0.9	0.18
4. Poultry reducing beef demand, open economy	2.9	0	2.9	0.29
5. Poultry reducing beef demand, open economy, international beef price 10% above current level	3.5	0	3.5	0.35

[1] Net present value of 50-year benefit stream, 10% discount rate.

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Table 2: Estimates of Internal Rate of Return and Their Sensitivity to Lags Between the Timing of Research Investments and Expected Benefits[1]

		IRR	
		Case 1	Case 3
A)	Benefits start in year 1	>100%	>100%
B)	Benefits start in year 6	29%	24%
C)	Benefits start in year 11	20%	15%

[1] US $20,000,000 annual research expenditures during 10 years, US $5,000,000 annual maintenance expenditures thereafter, 30 year benefit stream. Case 1: closed economy. Case 3: closed economy, poultry substitution.

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Table 3: Expected Changes in Beef Production, Consumption and Net Exports in the Latin American Tropics, and in Domestic Beef Prices, from Improved Pasture Research.

	% Increase Production	% Increase Consumption	Increase in Exports (million tons)	Domestic Beef Price	
				Before	After
Case 1	13	13	0	1625	1091
Case 2	55	3	2.5	1625	1500
Case 3	13	13	0	1310	880
Case 4	68	0	3.5	1500	1500
Case 5	68	0	3.7	1650	1650

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